

SUMMARY REPORT  
FOR

NAVAL SURFACE WARFARE CENTER, CARDEROCK DIVISION

LVS MOD DEMO VEHICLE  
ARMOR PROTECTION KIT INSTALLATION

NATC PROJECT NO. 17859

CONTRACT NUMBER:  
N00167-98-C-0017

AUGUST 2001

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# REPORT DOCUMENTATION PAGE

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<b>14. ABSTRACT</b> The purpose of this analysis was to discuss the two approaches to armor kits on vehicles, a bolt-on removable approach and an integrated approach. The study used a vehicle-modeling concept of a bolt-on removable armor approach and an integrated armor kit installed as a way to improve and modify the current protection for the LVS.					
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Standard Form 298 (Rev. 8-98)  
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## **1.0 BACKGROUND**

The Naval Surface Warfare Center, Carderock Division, contracted Simula Safety Systems, Inc., located in Tempe, Arizona, to install an armor protection kit on the Logistics Vehicle System (LVS). Concurrently, NATC was developing several Advanced Technology Demonstration (ATD) vehicles to support the USMC's LVSR program. The vehicle selected for the prototype installation of the armor kit was the Mod Demo LVS (MOD DEMO LVS) vehicle modified with the Raydan Air-Link tandem arm suspension at the #1, #2 #4 and #5 axles and a modified Hendrickson HT trailing arm air ride suspension at the #3 axle. This was an intermediate LVSR ATD vehicle built during 1998. The armor kit was installed from 23 - 25 July 2001 at the Nevada Automotive Test Center (NATC), located near Carson City, Nevada.

## **2.0 DESCRIPTION OF ARMOR KIT PROTECTION**

There are two approaches to armor kits on vehicles, a bolt-on removable approach and an integrated approach. The bolt-on approach adds approximately 900 pounds to a HMMVWV, 1,000 pounds to a 5-ton and 1,500 pounds to the HEMTT and LVS. These bolt-on kits are typically retrofit installations that secure the armor to the existing cab and vehicle structure without extensive modification to the vehicle. This type of approach was required by TACOM because the vehicles involved were used in different roles depending on the mission profile. When the high-risk mission was completed, the armor kit was simply removed from the vehicle and the vehicle returned to normal condition without the need to "fix" any structural modifications necessary for integral armor. Depending on the vehicle type and armor protection kit involved, there is some concern with bolt-on kits regarding fatigue and body mount degradation due to the added weight.

An alternate approach is the use of integrated armor mounted directly to the structural members of the vehicle. This approach also offers some degree of crash protection. For example, making the skid plate of armor material and integrating its mounting into the frame of the vehicle provides armor protection and crash protection in the event of a frontal collision at a fraction of the weight penalty. Because of the mounting, fatigue and body mount degradation is eliminated.

The prototype armor protection bolt-on kit installed by Simula Safety Systems, Inc. on the MOD DEMO LVS is composed of the same materials as the M977 HEMTT armor kit that was developed for TACOM. The kit will defeat the 7.62 mm M80 ball projectile at muzzle (2,750 fps) velocity for both the opaque and transparent armor components. The kit was designed to stop all horizontal shots fired at the vehicle. The roof was designed to defeat shots made at 30 degrees obliquity. The LVS has not been tested for mine blast, however, the HEMTT was tested at Aberdeen Test Center using Soviet TM-46 anti-tank mines (12 pounds TNT equivalent). The LVS kit employs the same type of blast deflectors. This mine testing was conducted for wheel-detonated mines. However, due to the clearances for the #1 axle nose box on the LVS, underbody blast protection is reduced.

### 3.0 SUMMARY

The prototype armor protection kit was installed on the LVS by Simula from 23 - 25 July 2001. Measurements and mockups were recorded in February 2000 and August 2000. The armor kit will need refinement before it becomes a production item. The following is a list of items that need to be addressed should this kit become a kit option for the LVS:

1. The black out lights were not connected through the armor kit (Photograph number 20238-001),
2. The upper clearance lights were not connected through the armor kit (Photograph number 20238-001),
3. Visibility is limited/restricted by the new cab enclosure (Photographs numbered 20238-030 and 031),
4. The air flow is restricted to the cab (Photographs numbered 20238-030 and 031),
5. The window locks may protrude into the occupant's head/body during an accident (Photograph number 20238-016),
6. The door handle (inside cab) is hard to reach next to the seat (Photographs numbered 20238-019 and 020),

7. There is no exit point for the occupants during an accident; i.e., the window can not be kicked out (Photographs numbered 20238-001 through 004),
8. The dead bolt door locks automatically lock during vehicle operation (Photographs numbered 20238-017 and 018),
9. The bolts in the roof are protruding into the cab area creating a probability of head injury (Photographs numbered 20238-013 and 015),
10. The roof hatch is hard to lift and does not seem to slide; no 95th percentile provisions (Photographs numbered 20238-004 and 005),
11. The entire cab has protruding bolts into the cab space creating a probability of head injuries (Photographs numbered 20238-013, 014, 015, 023, 024, 025 and 027),
12. The underbody plate will act as a mud trap and corrosion issues are probable (Photographs numbered 20238-003 and 029),
13. The doors are too heavy for the hinges; occupants get trapped inside the vehicle due to hinges getting off track (Photograph number 20238-010),
14. The armor kit is bolted through the gunner's platform; platform not operational (Photographs numbered 20238-024 and 027),
15. The cab structure tube is crushed due to no support for bolts (Photograph number 20238-025),
16. The driver and passenger side upper door pins are loose (Photograph number 20238-011),
17. There is a gap in the armor plate on both sides; only one bolt holds the armor kit on, the other bolt is only through the sheet metal (Photograph number 20238-012),
18. There is no thread engagement on the nylon bolts inside the cab in the front and gunner's hatch areas (Photograph number 20238-026),

19. There is no access to clean the headlights; space will serve as a mud trap (Photograph number 20238-028), and
20. The cab mounts are deteriorating due to the additional weight (Photographs numbered 20238-021 and 022).

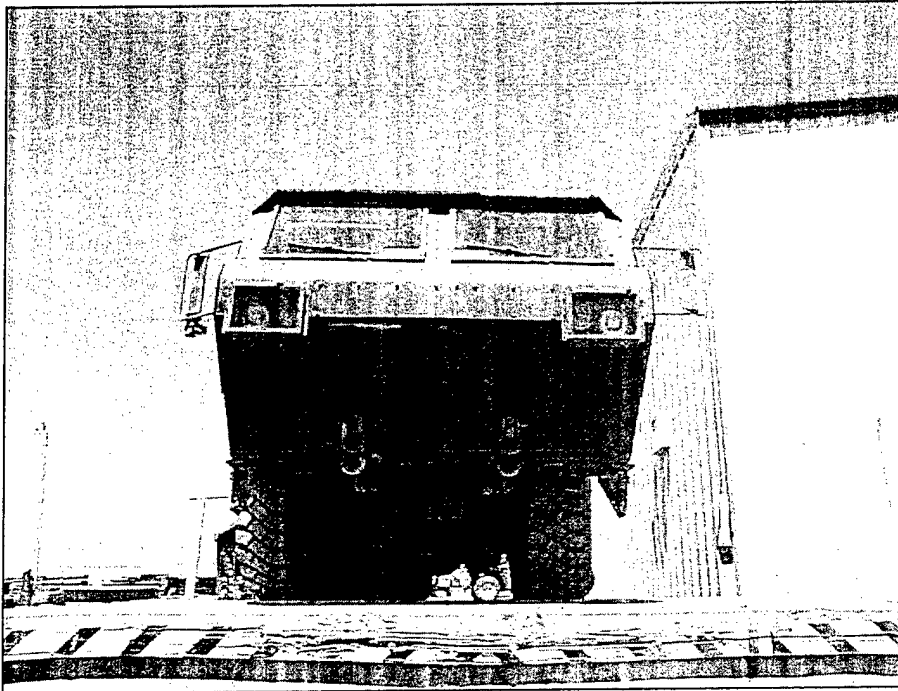
It is recommended that these items be addressed should this kit become a LVS option.

This kit was developed from the M977 (HEMTT) armor kit. The HEMTT kit was developed under short timelines for use in Bosnia. The HEMTT kit was designed, fabricated and tested in 3 months time, which left little time for any detailed structural analysis. All operating acceptance testing was done at Yuma Proving Grounds (YPG) and the results recorded at the M977 PM office at TACOM. The ballistic testing was performed at Aberdeen Test Center (ATC) and the results recorded at the M977 PM office at TACOM. While the HEMTT (and therefore the LVS) kit has some shortcomings, the intent of fielding a "bolt-on" kit for use in a major military deployment was achieved. Some of these changes are simple and can be accomplished with little effort (as in changing the protruding bolts to face outward), and some will require more effort (such as emergency escape during roll over).

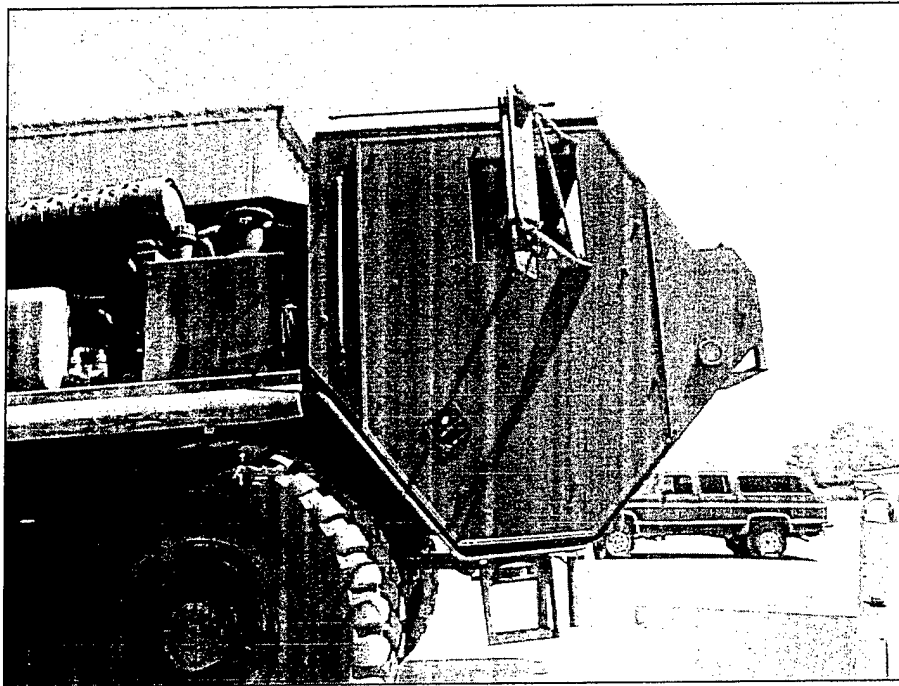
#### **4.0 RECOMMENDATIONS**

1. Address the twenty-one items identified should further development be merited.
2. Perform accelerated fatigue testing of the vehicle.
3. Redesign the cab mounts to consist of a stiffer material.

APPENDIX A  
PHOTOGRAPHIC SUPPLEMENT

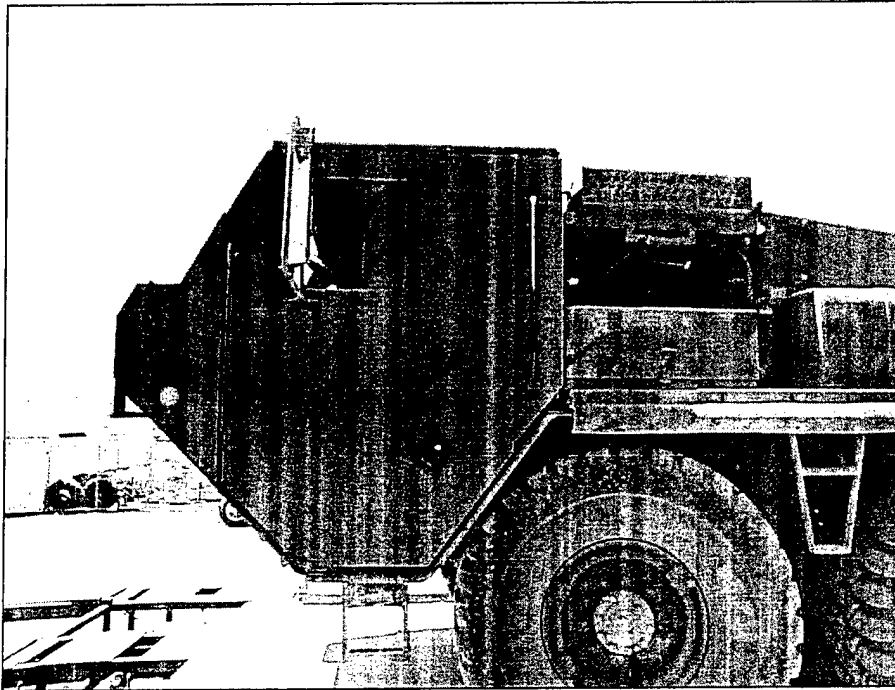


PHOTOGRAPH NO. 20238-001  
LVS ARMOR PROTECTION KIT  
FRONT VIEW

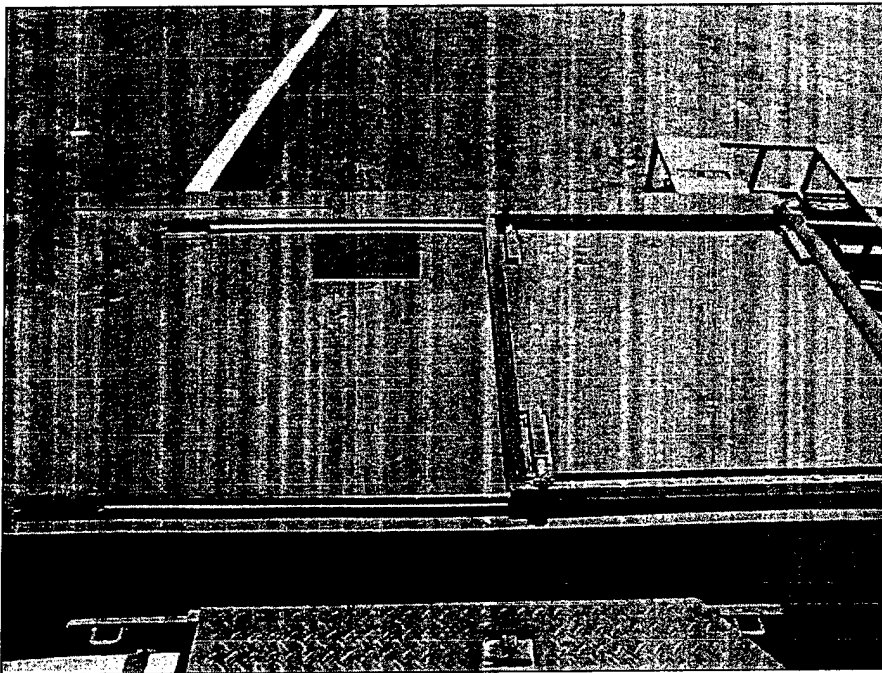


PHOTOGRAPH NO. 20238-002  
LVS ARMOR PROTECTION KIT  
PASSENGER SIDE VIEW

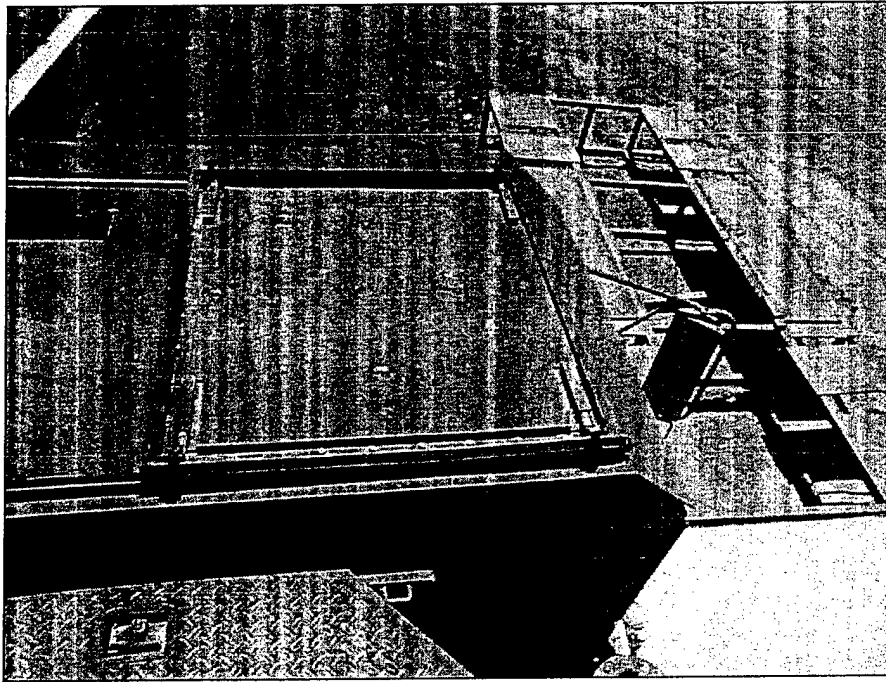




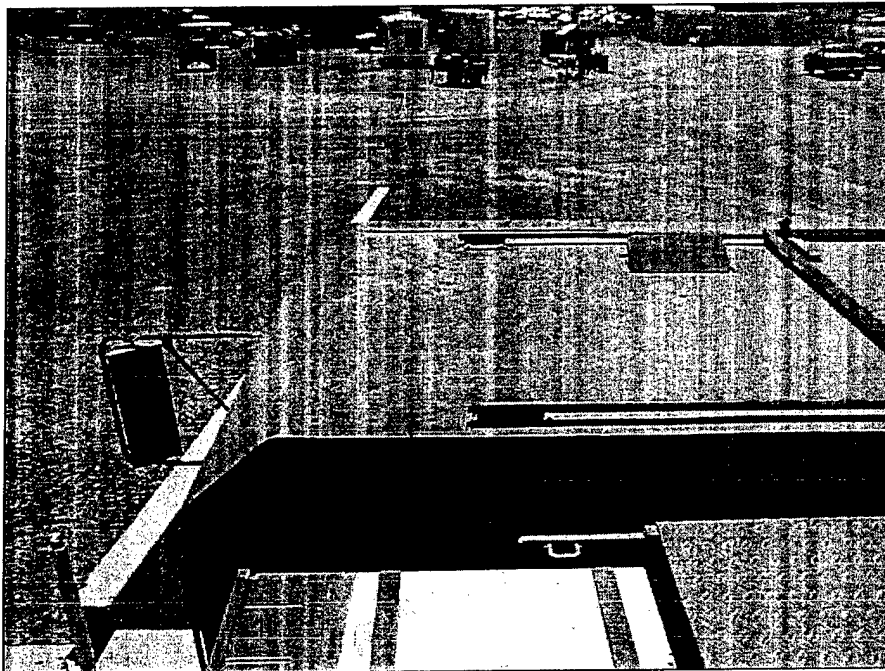
PHOTOGRAPH NO. 20238-003  
LVS ARMOR PROTECTION KIT  
DRIVER SIDE VIEW



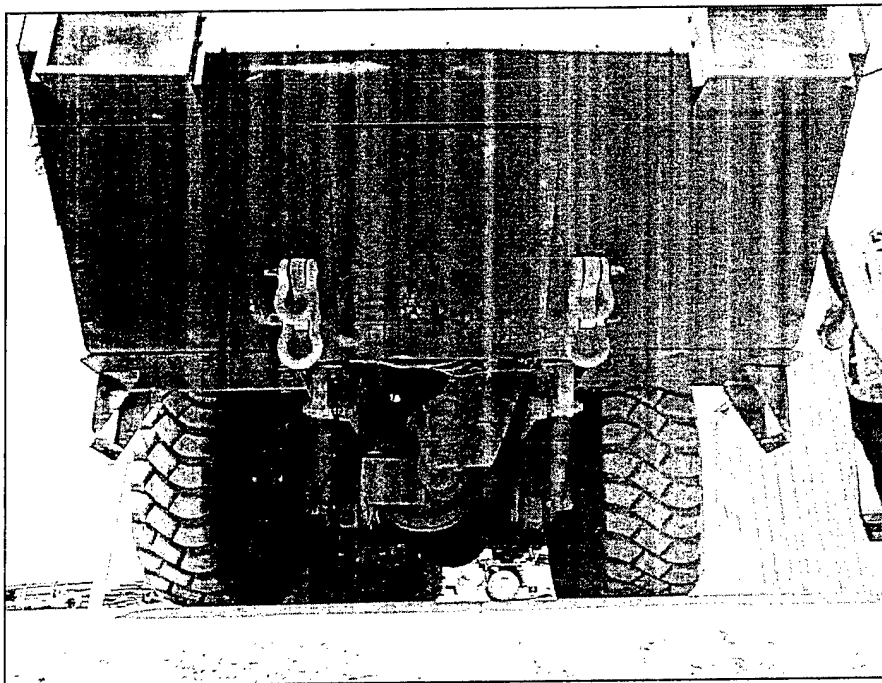
PHOTOGRAPH NO. 20238-004  
LVS ARMOR PROTECTION KIT  
TOP CENTER VIEW



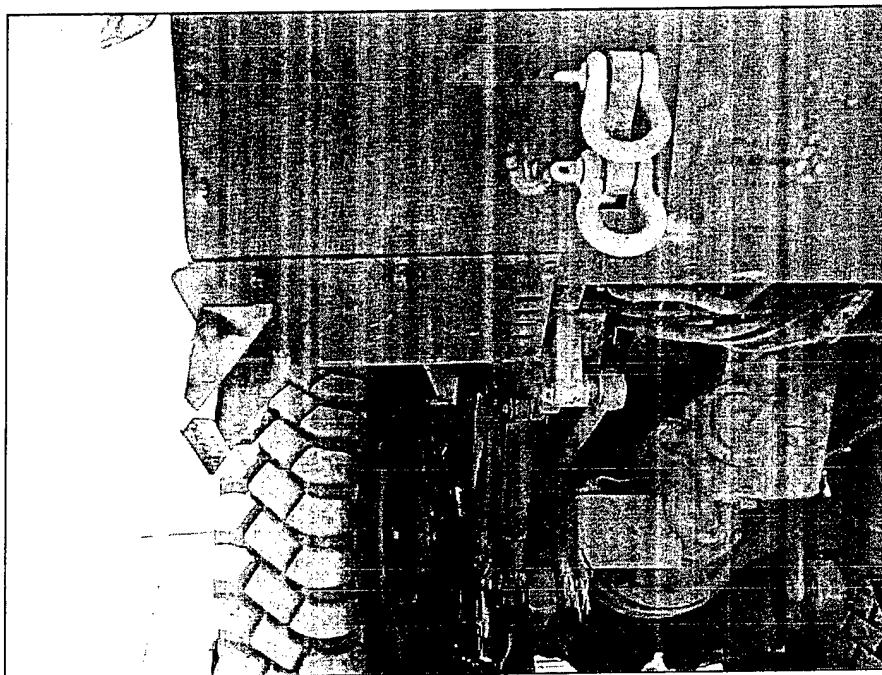
PHOTOGRAPH NO. 20238-005  
LVS ARMOR PROTECTION KIT  
TOP PASSENGER SIDE VIEW



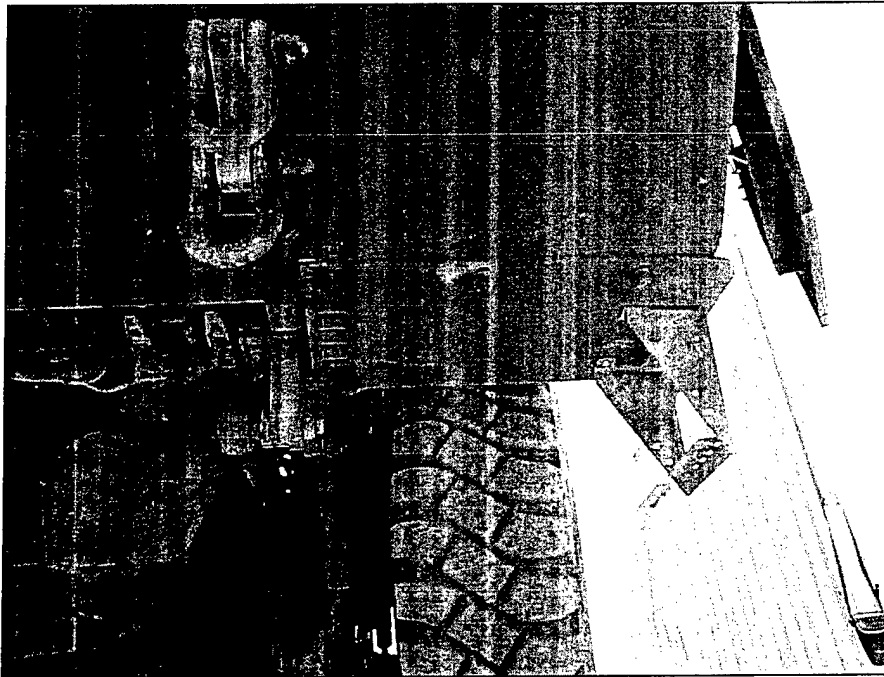
PHOTOGRAPH NO. 20238-006  
LVS ARMOR PROTECTION KIT  
TOP DRIVER SIDE VIEW



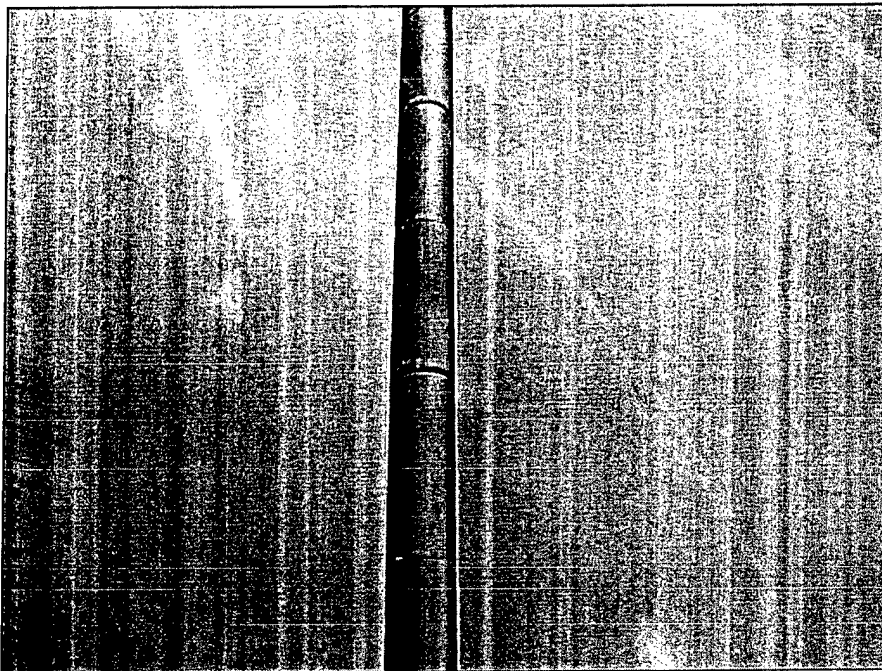
PHOTOGRAPH NO. 20238-007  
LVS ARMOR PROTECTION KIT  
FRONT UNDERCARRIAGE VIEW



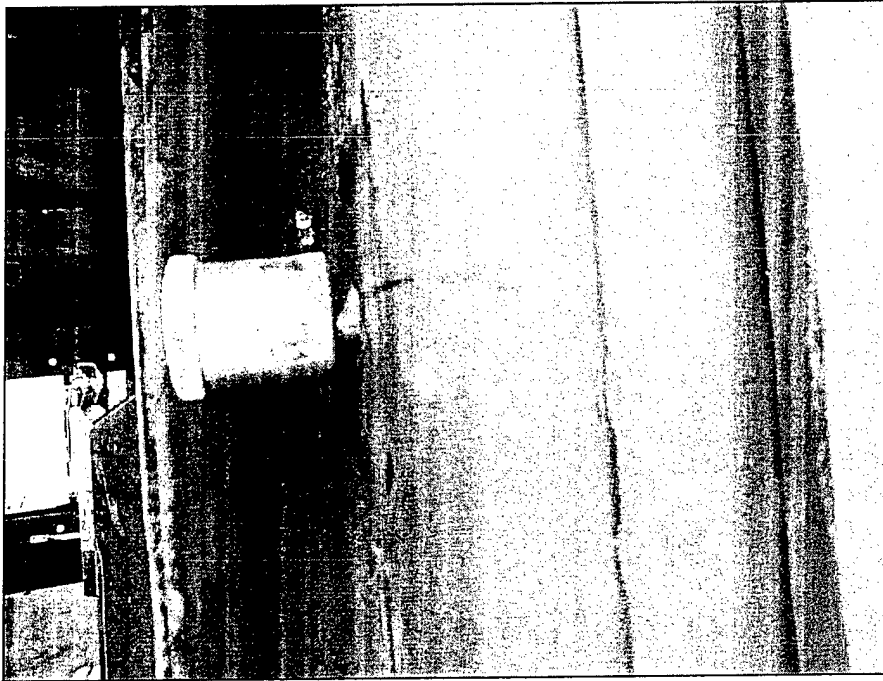
PHOTOGRAPH NO. 20238-008  
LVS ARMOR PROTECTION KIT  
FRONT UNDERCARRIAGE PASSENGER SIDE VIEW



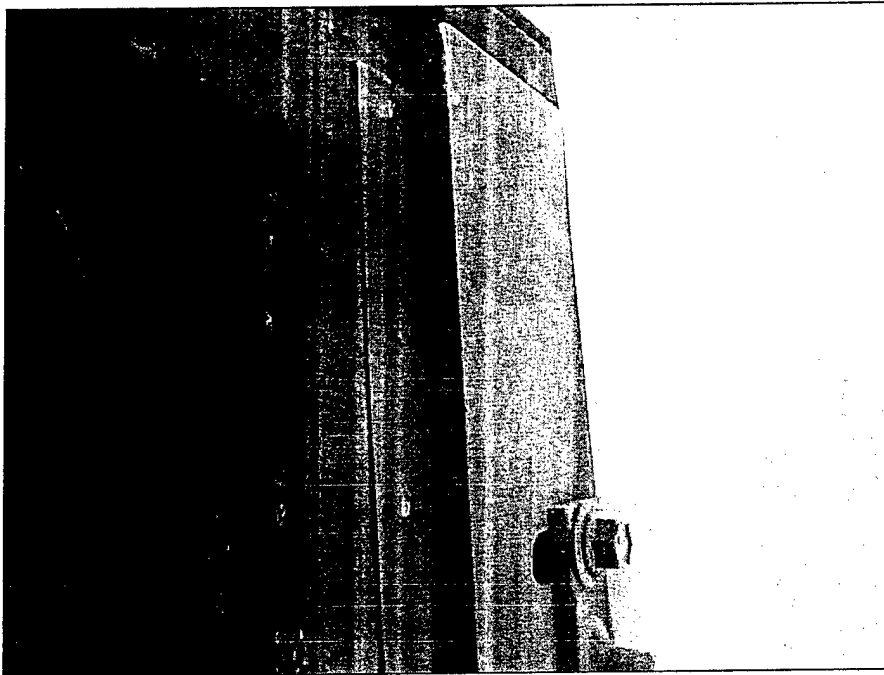
PHOTOGRAPH NO. 20238-009  
LVS ARMOR PROTECTION KIT  
FRONT UNDERCARRIAGE DRIVER SIDE VIEW



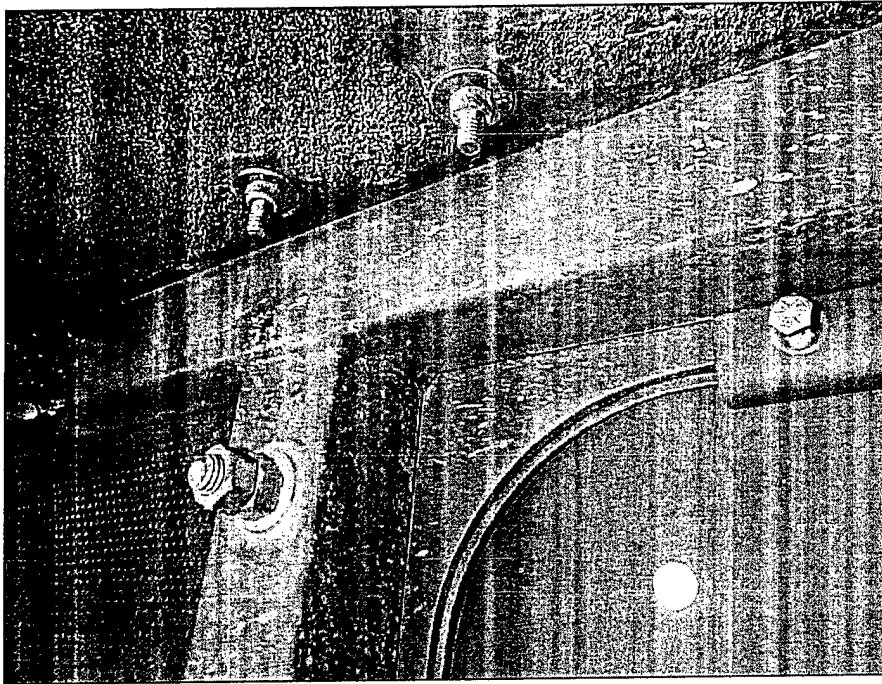
PHOTOGRAPH NO. 20238-010  
LVS ARMOR PROTECTION KIT  
DRIVER SIDE DOOR HINGE



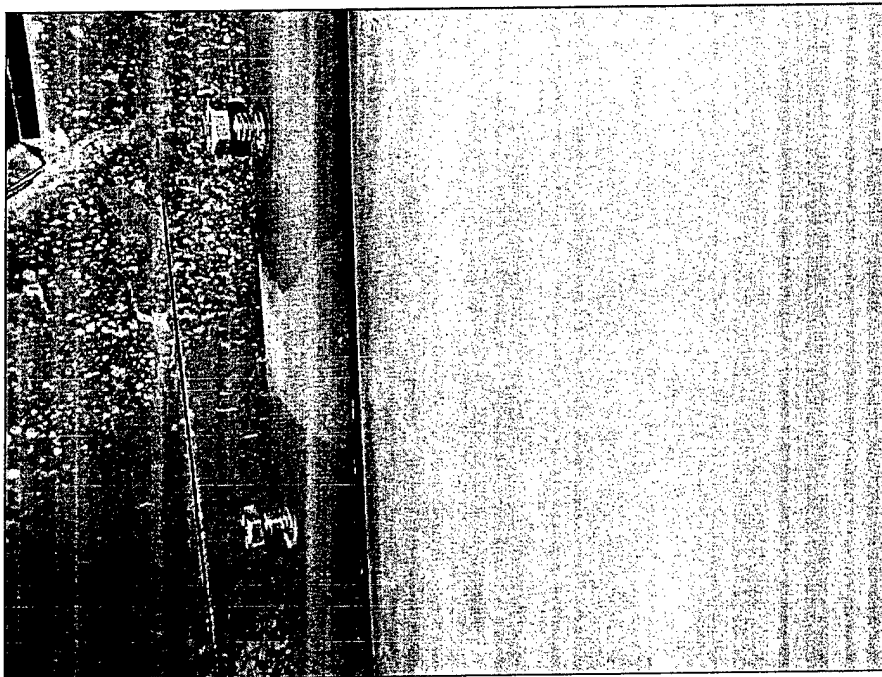
PHOTOGRAPH NO. 20238-011  
LVS ARMOR PROTECTION KIT  
UPPER DOOR PIN LOOSE – CONTACT MARKS FROM DOOR



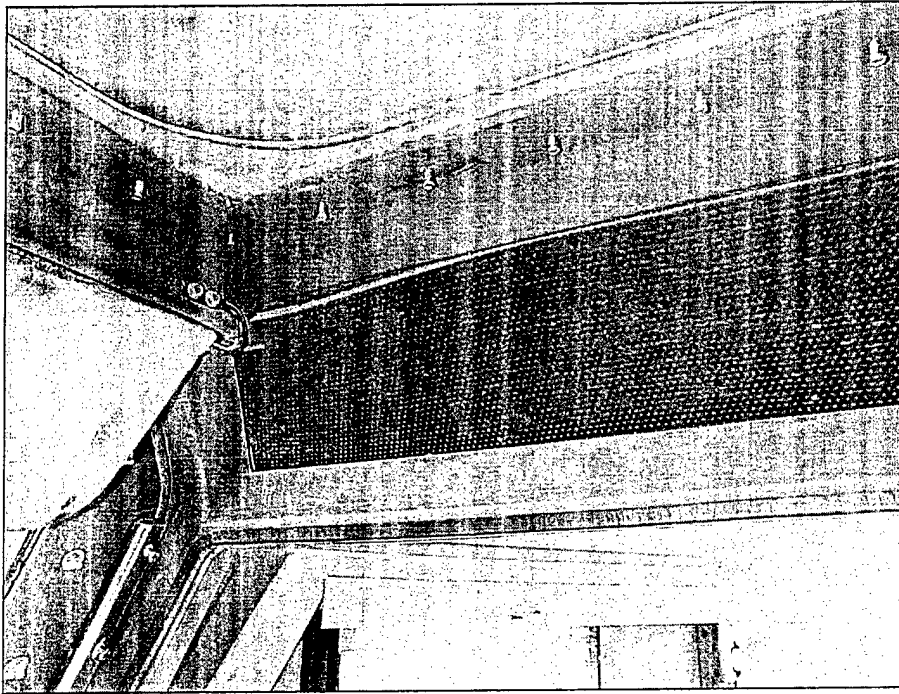
PHOTOGRAPH NO. 20238-012  
LVS ARMOR PROTECTION KIT  
ARMOR PLATE NOT CONNECTED PROPERLY –  
GAP BETWEEN PLATE AND CAB



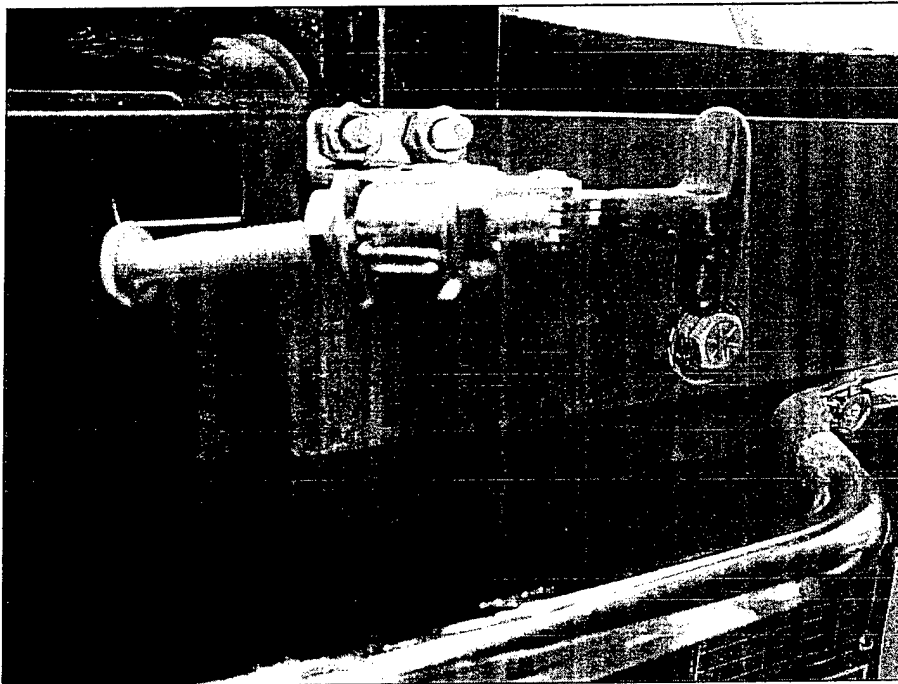
PHOTOGRAPH NO. 20238-013  
LVS ARMOR PROTECTION KIT  
PROTRUDING BOLTS – DRIVER'S SIDE ROOF



PHOTOGRAPH NO. 20238-014  
LVS ARMOR PROTECTION KIT  
PROTRUDING BOLTS BEHIND DRIVER'S SEAT

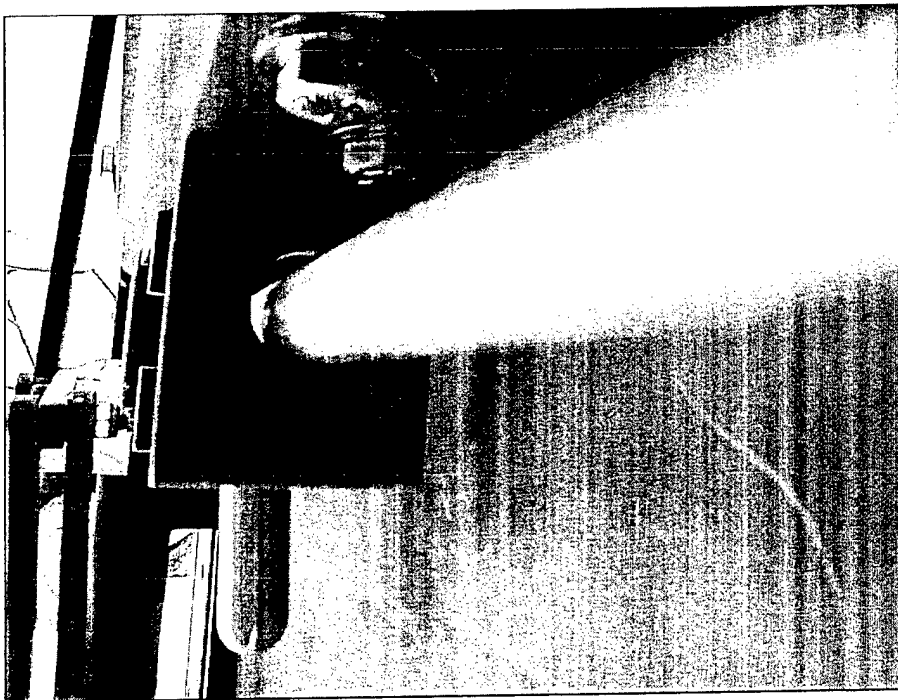


PHOTOGRAPH NO. 20238-015  
LVS ARMOR PROTECTION KIT  
PROTRUDING BOLTS – PASSENGER'S SIDE HATCH

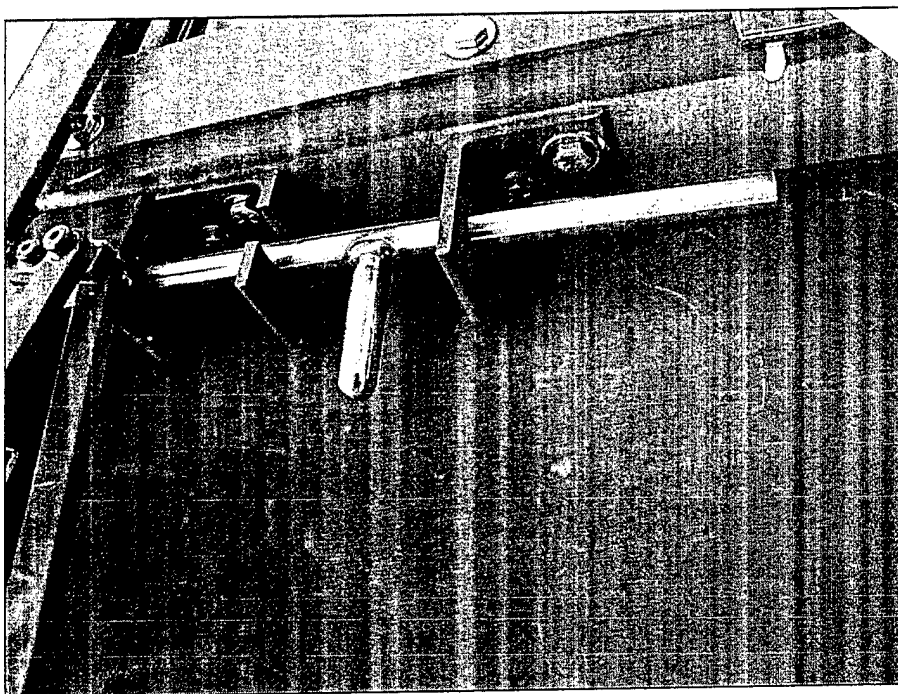


PHOTOGRAPH NO. 20238-016  
LVS ARMOR PROTECTION KIT  
WINDOW LOCKS NOT TIGHT/OPERATIONAL



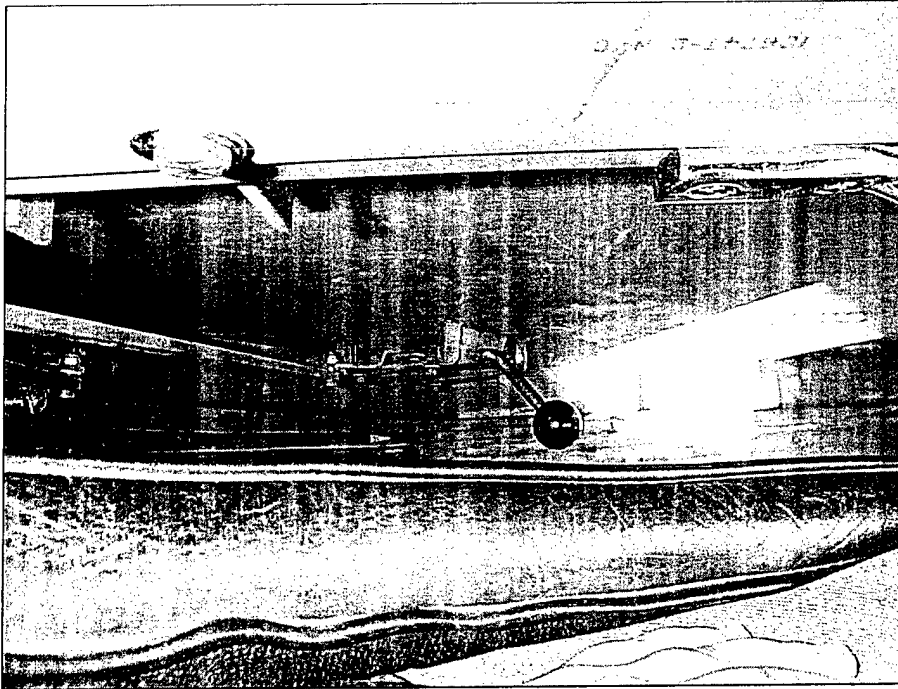


PHOTOGRAPH NO. 20238-017  
LVS ARMOR PROTECTION KIT  
DEAD BOLT DOOR LOCK NOT TIGHT - RATTLES

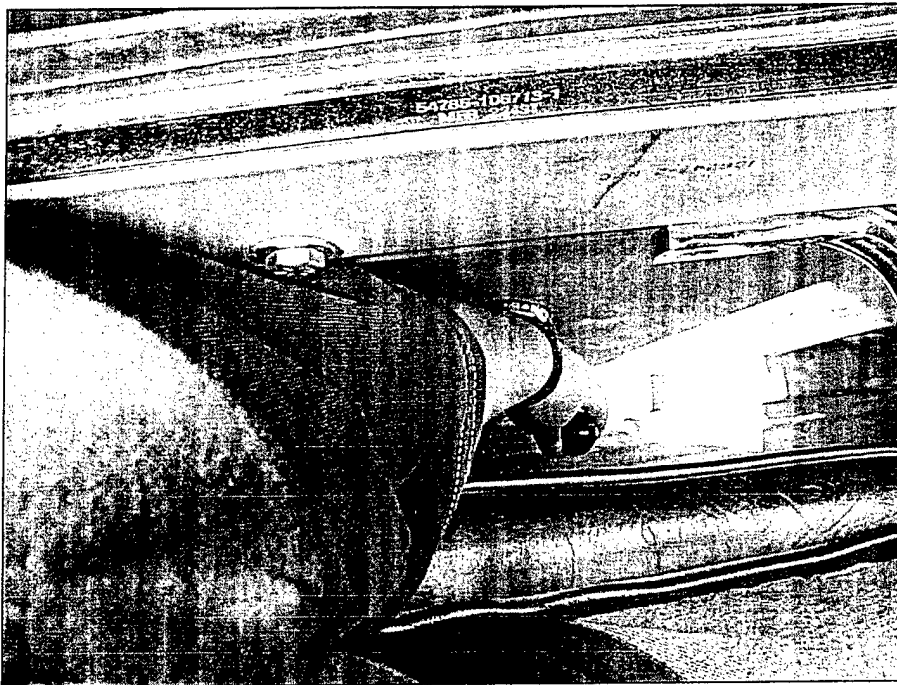


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LVS ARMOR PROTECTION KIT  
DEAD BOLT DOOR LOCK NOT TIGHT - RATTLES

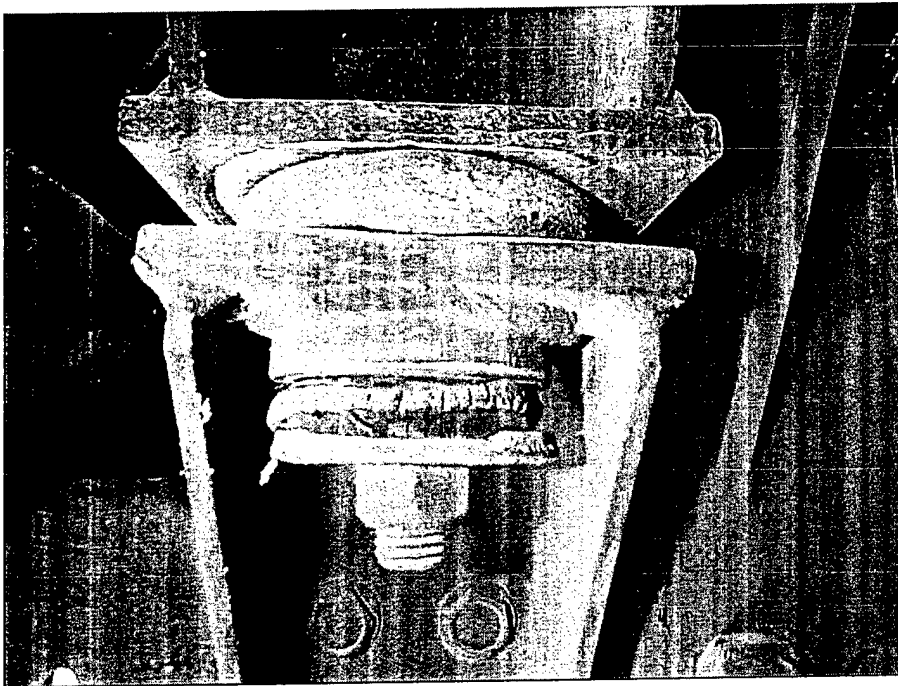




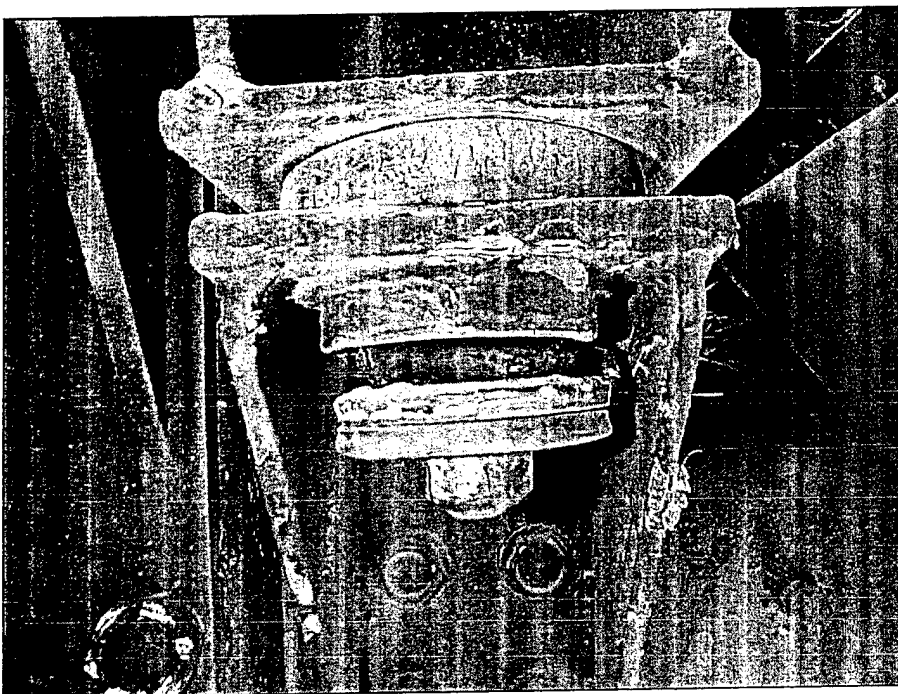
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LVS ARMOR PROTECTION KIT  
DOOR HANDLE LOCATION



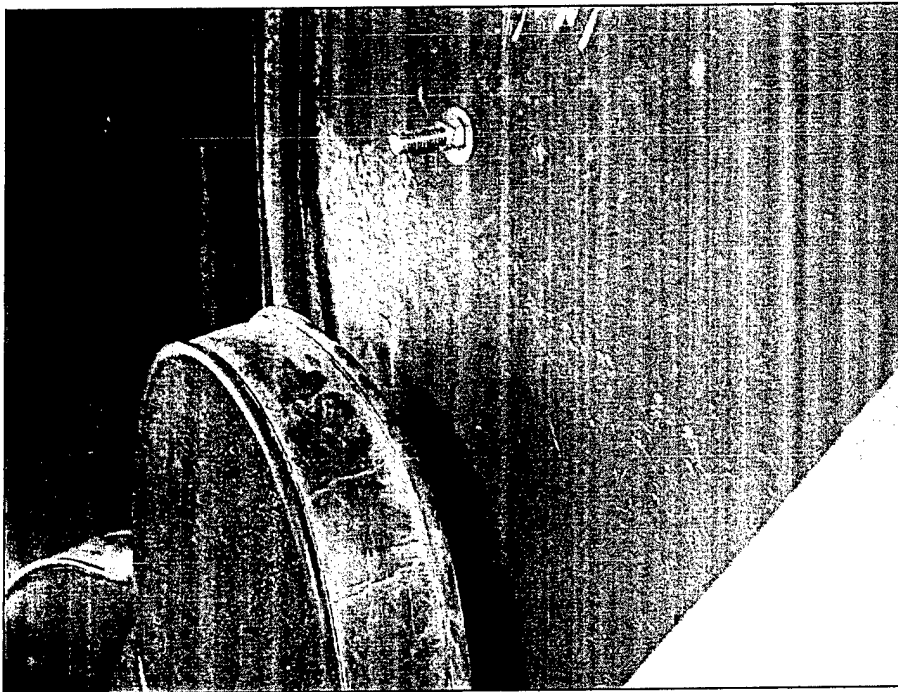
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LVS ARMOR PROTECTION KIT  
DOOR HANDLE LOCATION



PHOTOGRAPH NO. 20238-021  
LVS ARMOR PROTECTION KIT  
DRIVER SIDE CAB MOUNTS



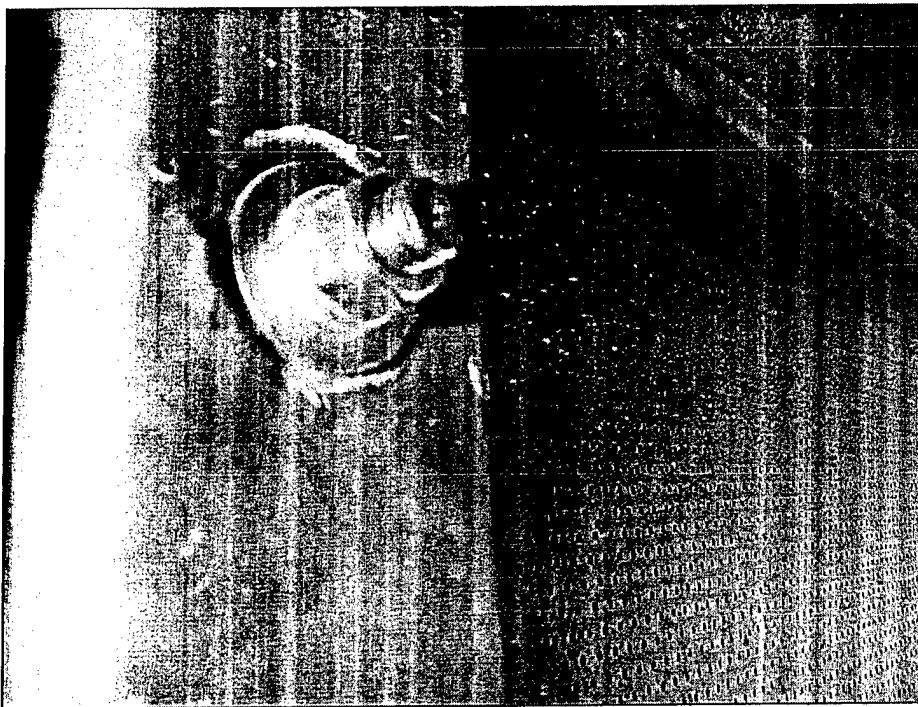
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LVS ARMOR PROTECTION KIT  
PASSENGER SIDE CAB MOUNTS



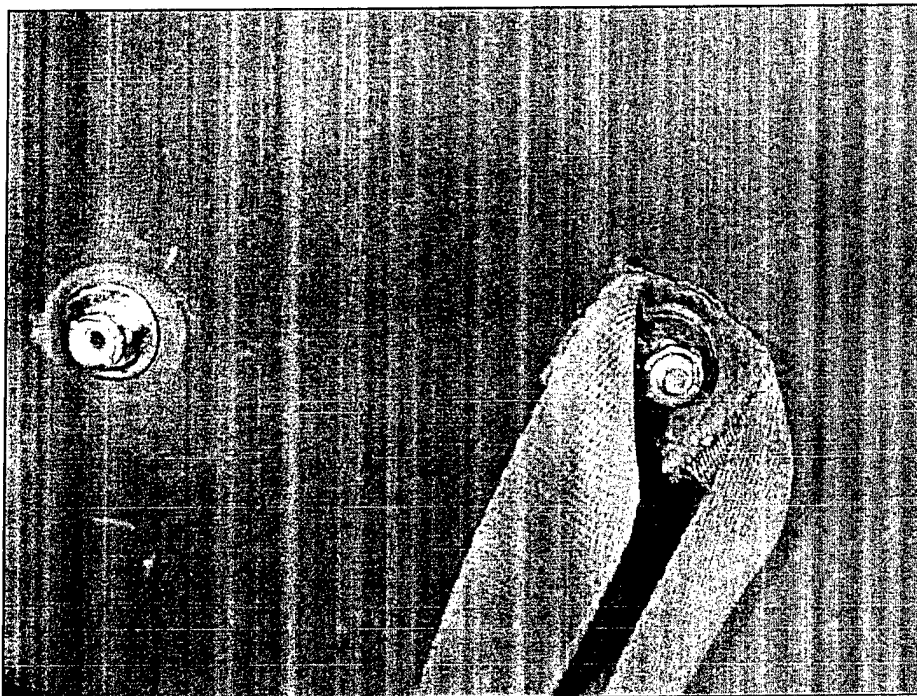
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LVS ARMOR PROTECTION KIT  
PROTRUDING BOLTS PASSENGER SIDE



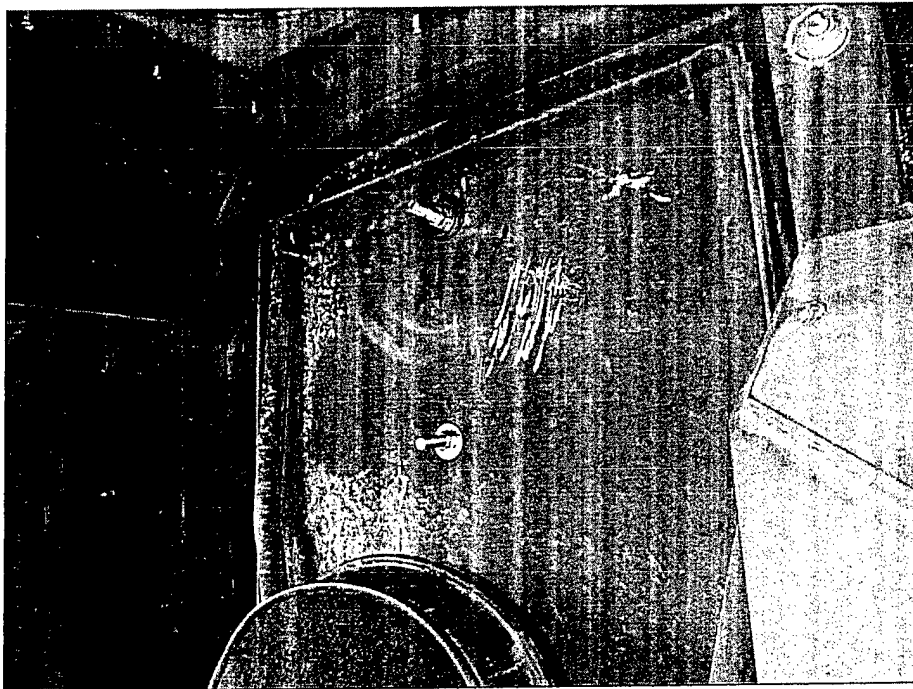
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LVS ARMOR PROTECTION KIT  
PROTRUDING BOLTS PASSENGER SIDE



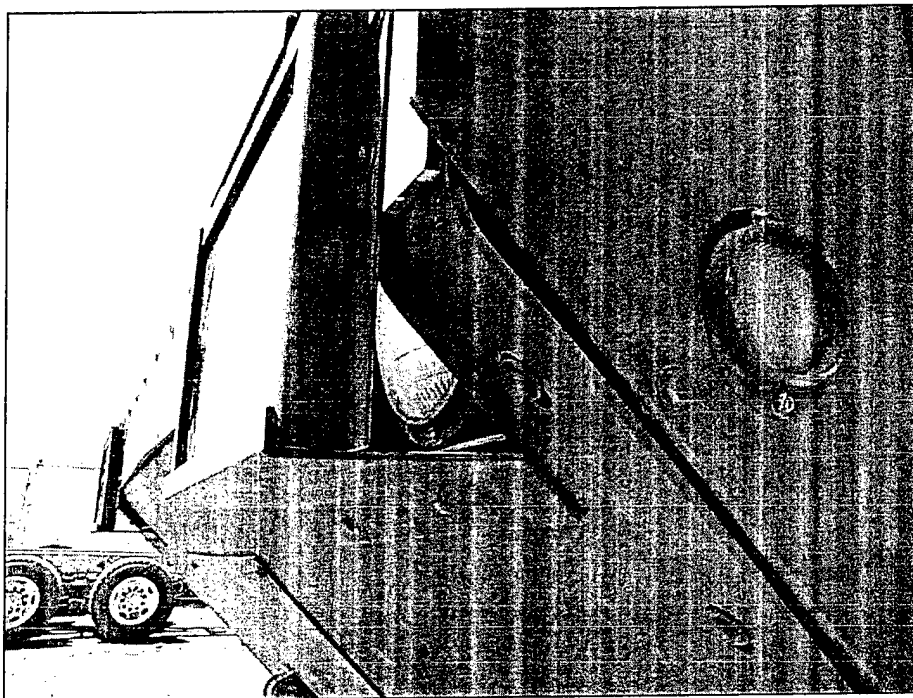
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LVS ARMOR PROTECTION KIT  
CRUSHED CAB STRUCTURE TUBE



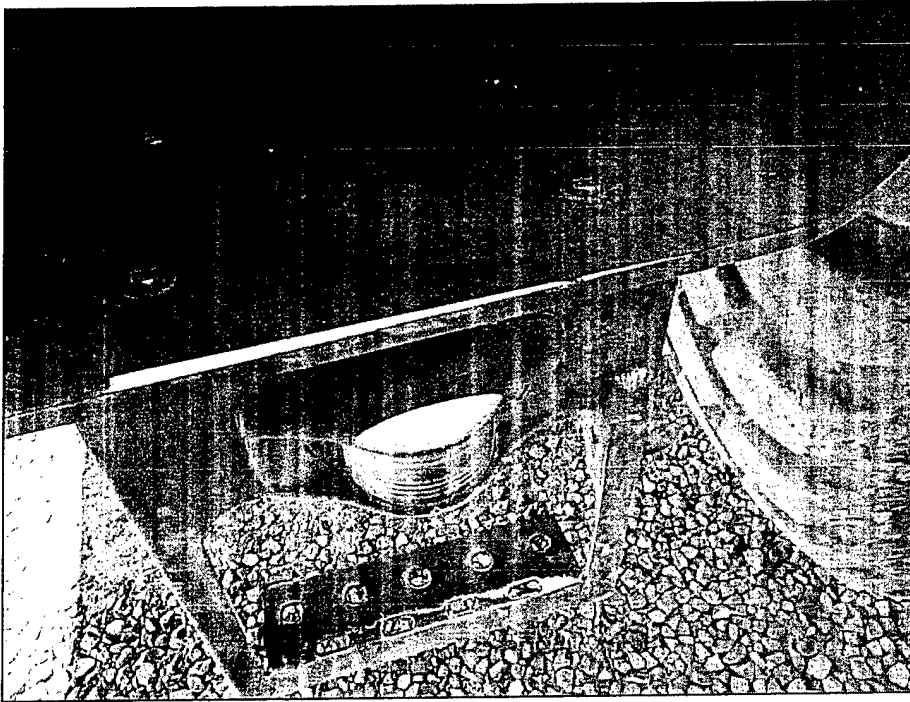
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LVS ARMOR PROTECTION KIT  
NYLON BOLT NOT ENGAGED



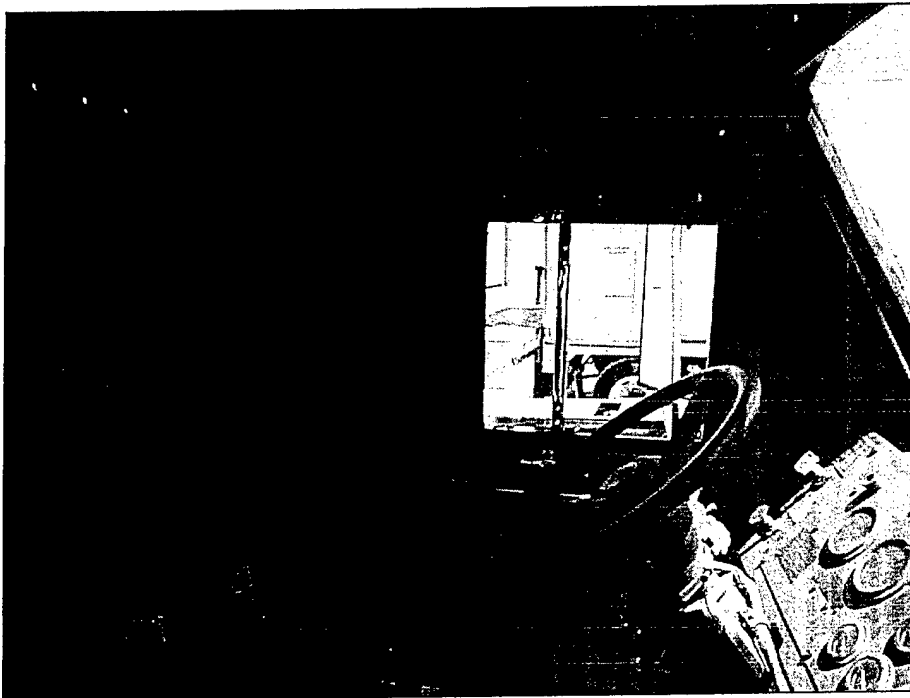
PHOTOGRAPH NO. 20238-027  
LVS ARMOR PROTECTION KIT  
GUNNER'S PLATFORM BOLTED TO ARMOR



PHOTOGRAPH NO. 20238-028  
LVS ARMOR PROTECTION KIT  
HEADLIGHT ACCESS ELIMINATED/ MUD TRAP AREA



PHOTOGRAPH NO. 20238-029  
LVS ARMOR PROTECTION KIT  
NO TRACTION ON ARMOR PLATE STEP



PHOTOGRAPH NO. 20238-030  
LVS ARMOR PROTECTION KIT  
DRIVER'S VISIBILITY